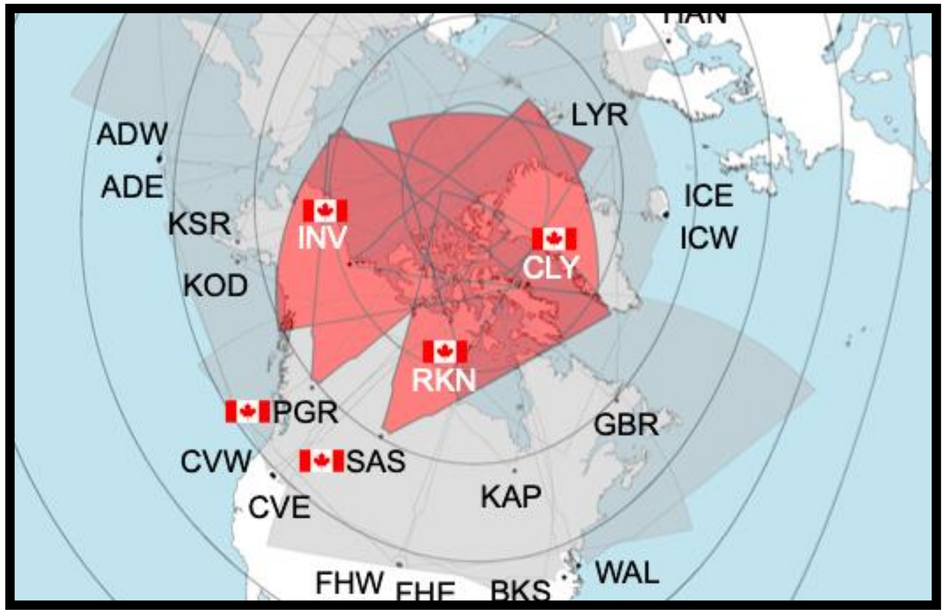
SUPERDARN CANADA



High time resolution mapping of polar ionospheric flows with the SuperDARN Borealis systems

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K. A. McWilliams
C. J. Martin
K. M. Laundal
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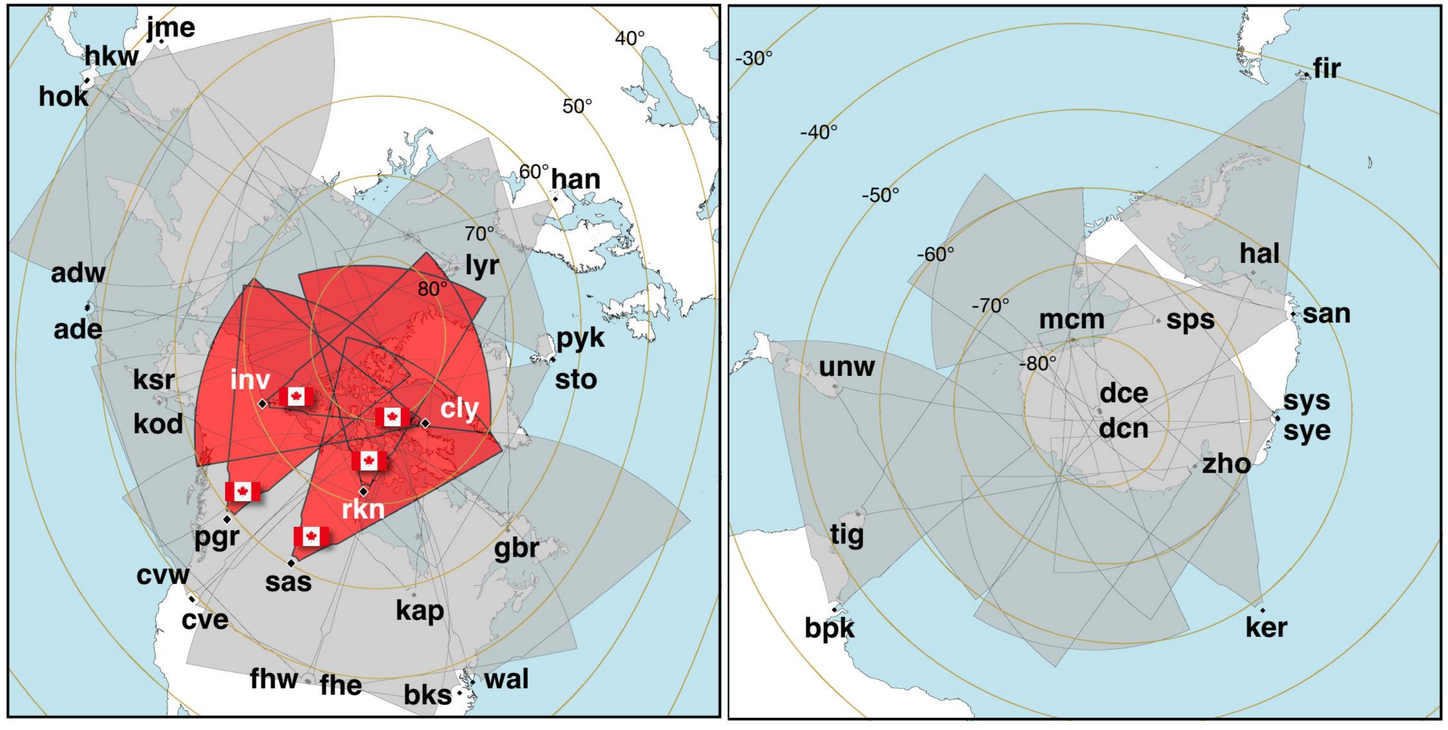
University of Saskatchewan

What is SuperDARN?

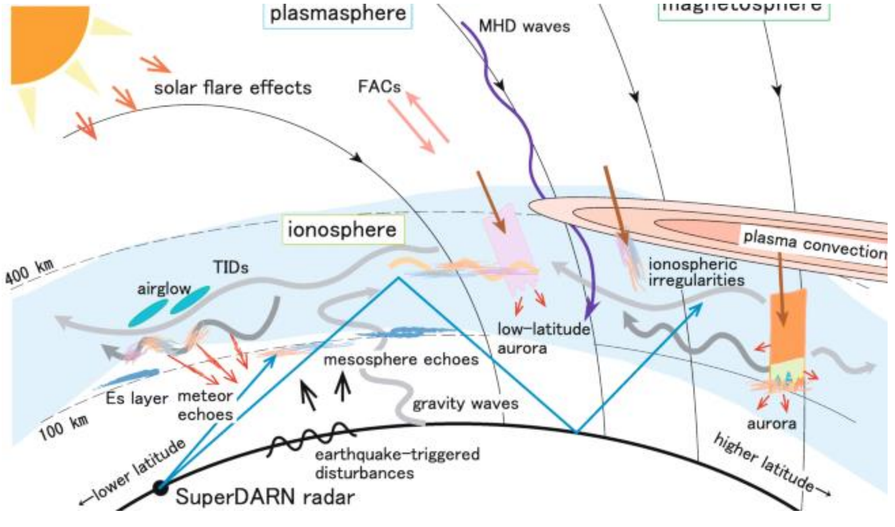


International collaboration of 35+ HF radars

SuperDARN Canada operate 5 radars. 3 ìPolarDARNî and 2 ìAuroraDARNî.

Each radar measures line-of-sight ionospheric drifts

High-frequency radio transmissions from each radar **refract** in the ionosphere and **scatter** off of field-aligned irregularities



Narrow-beam scanning VS Wide-beam imaging

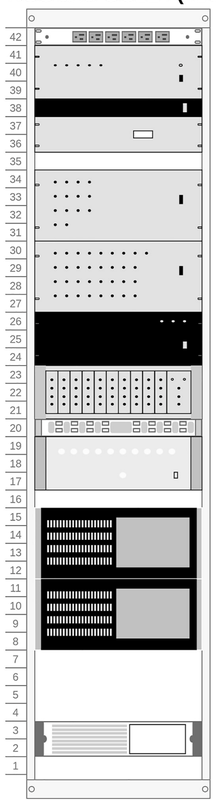
Traditional (analogue)

τ = 1 minute,
3.5s per beam

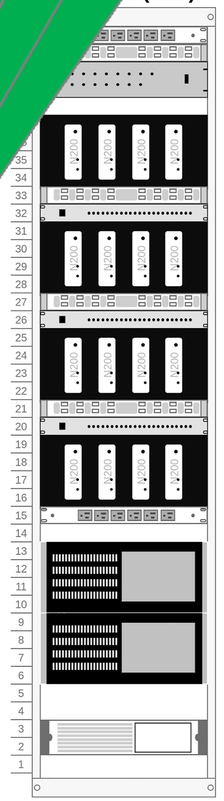
Borealis (digital)

τ = 3.5 s

ROS and GC214 (42U)



s (42U)

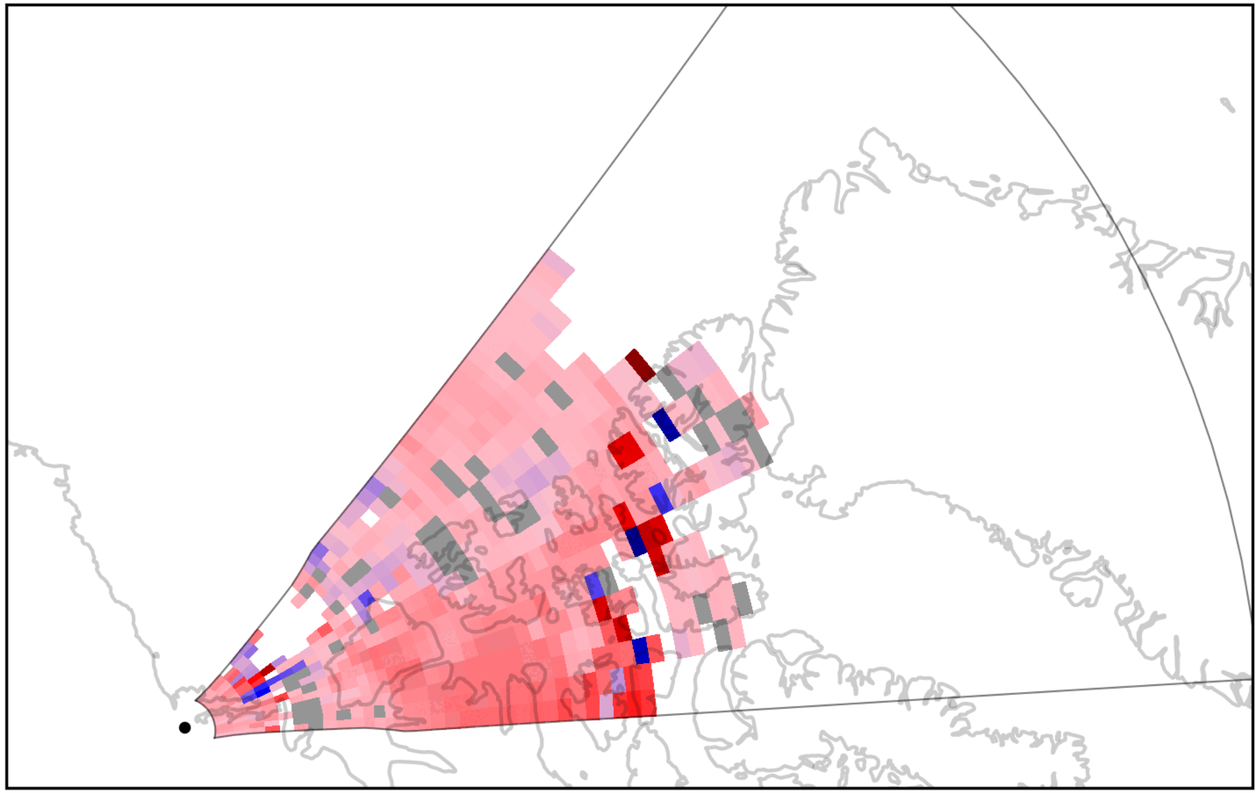


McWilliams et al., 2022

Old vs New – Mode Switching Experiment

Traditional narrow-beam scanning

2023-12-17 01:38:33



Borealis wide-beam imaging

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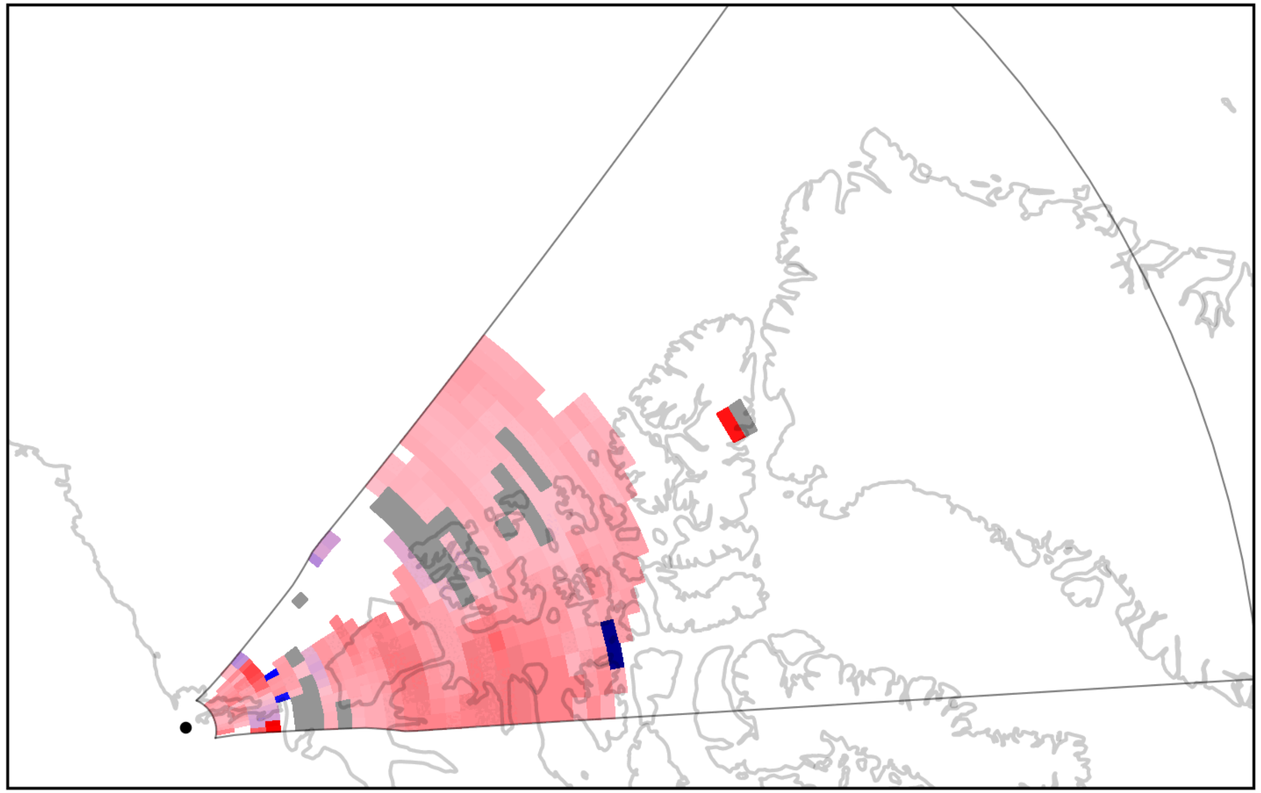
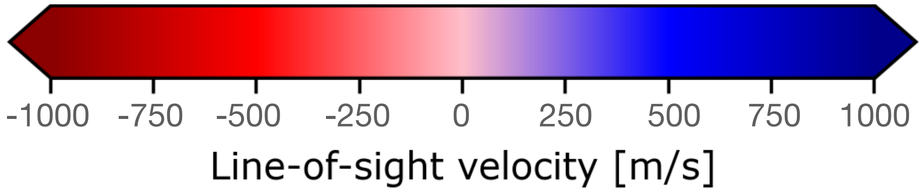
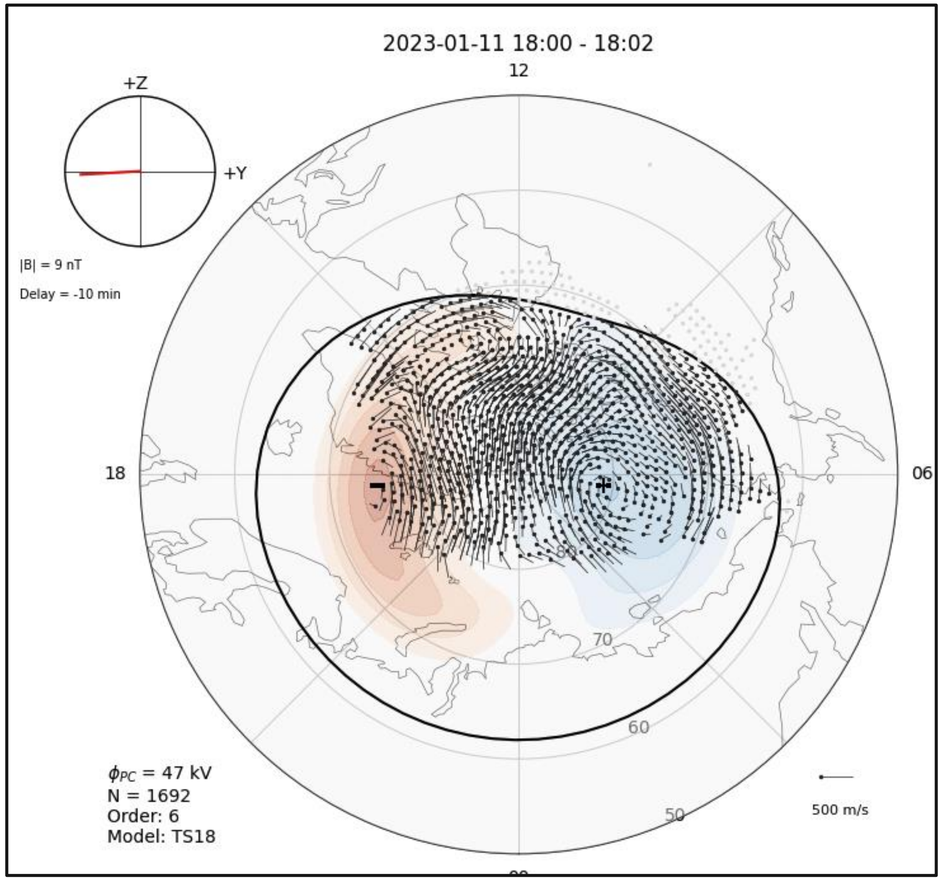
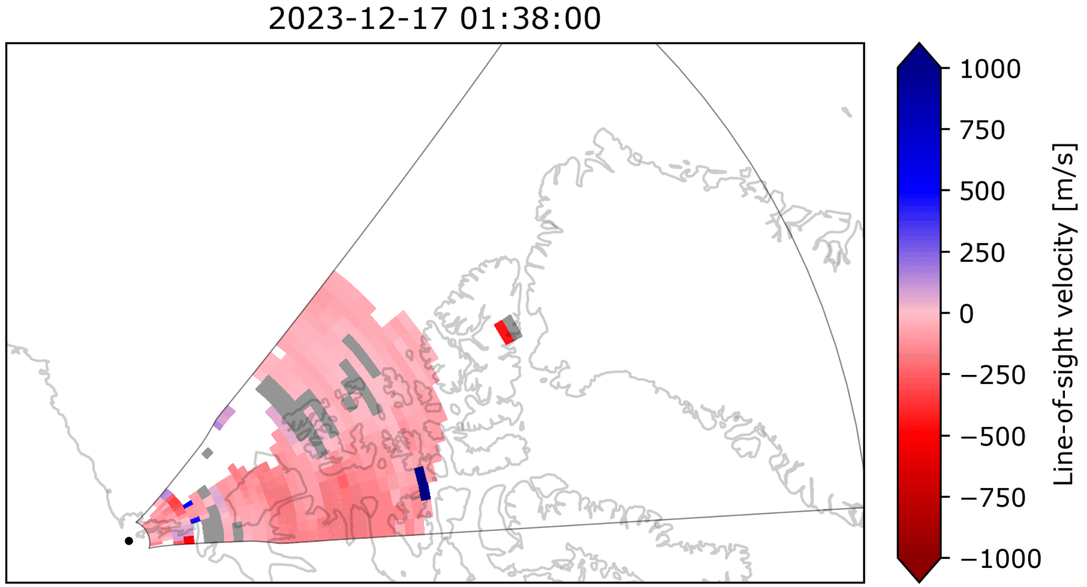


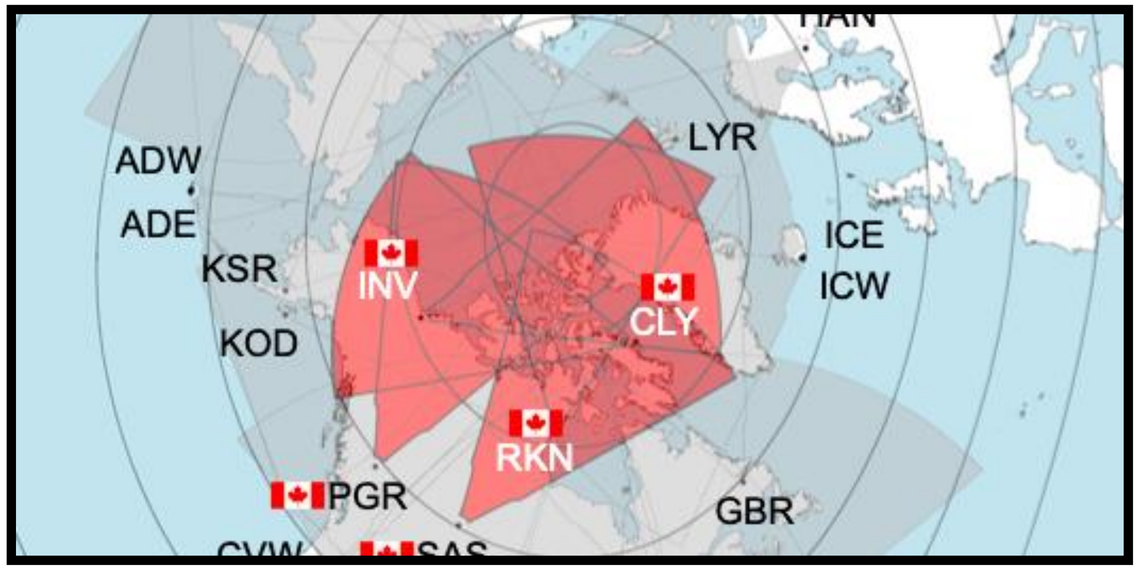


Inuvik, Full-FOV, 2023-12-17

What if we could make a Borealis ionospheric convection map?

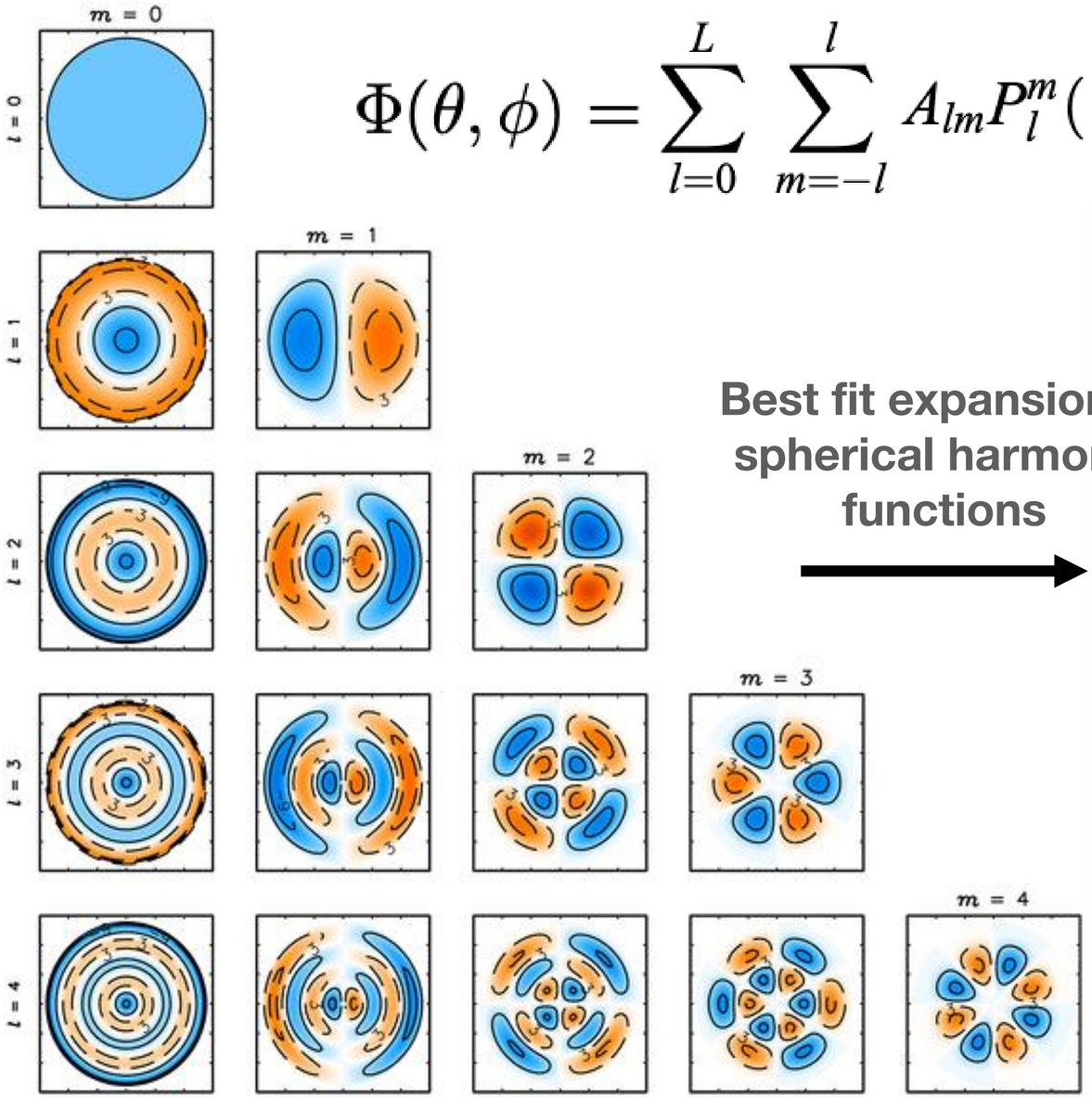






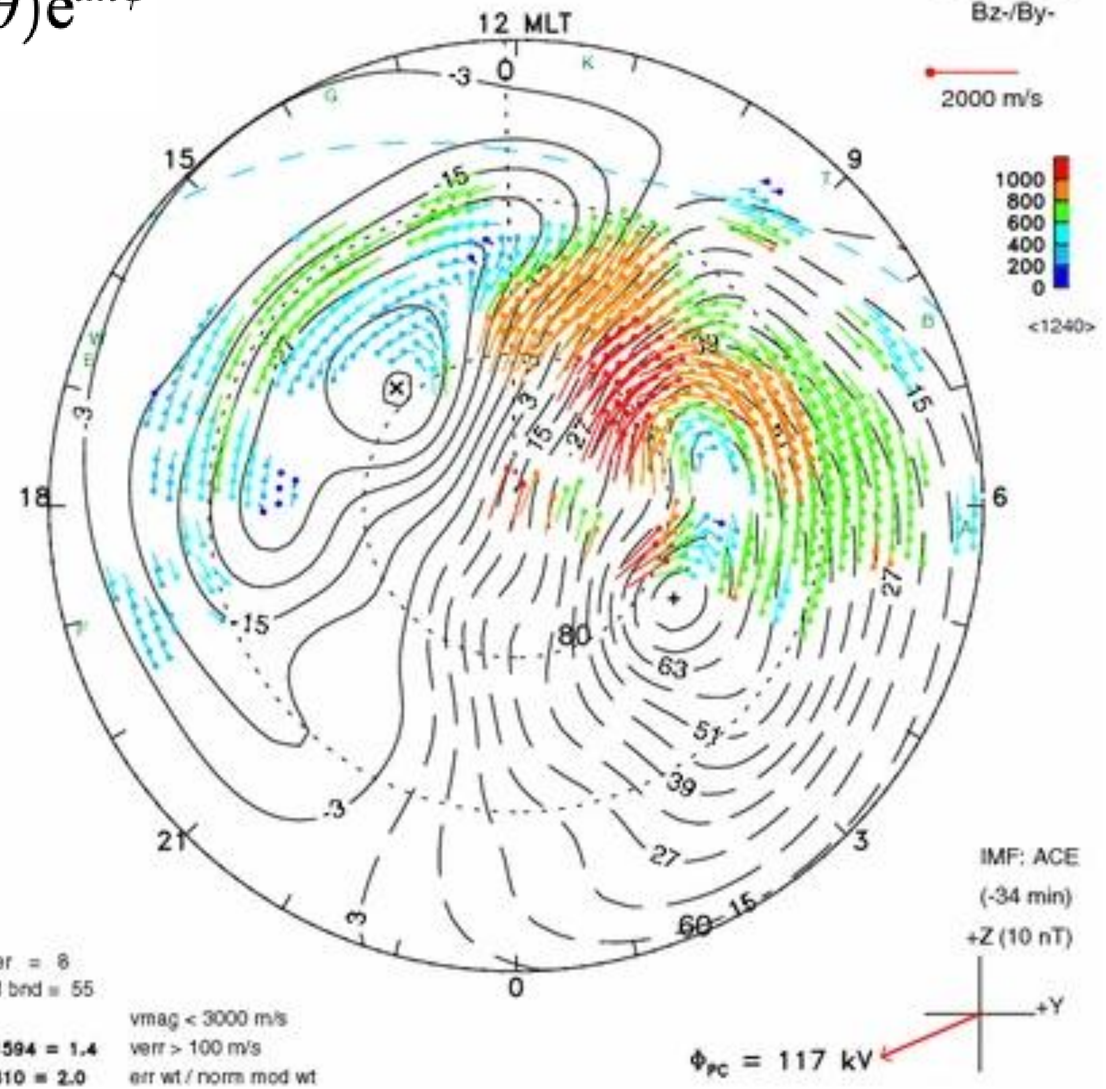
Traditional SuperDARN Convection Patterns

$$\Phi(\theta,\phi) = \sum_{l=0}^{L} \sum_{m=-l}^{l} A_{lm} P_l^m(\cos\theta) e^{im\phi}$$



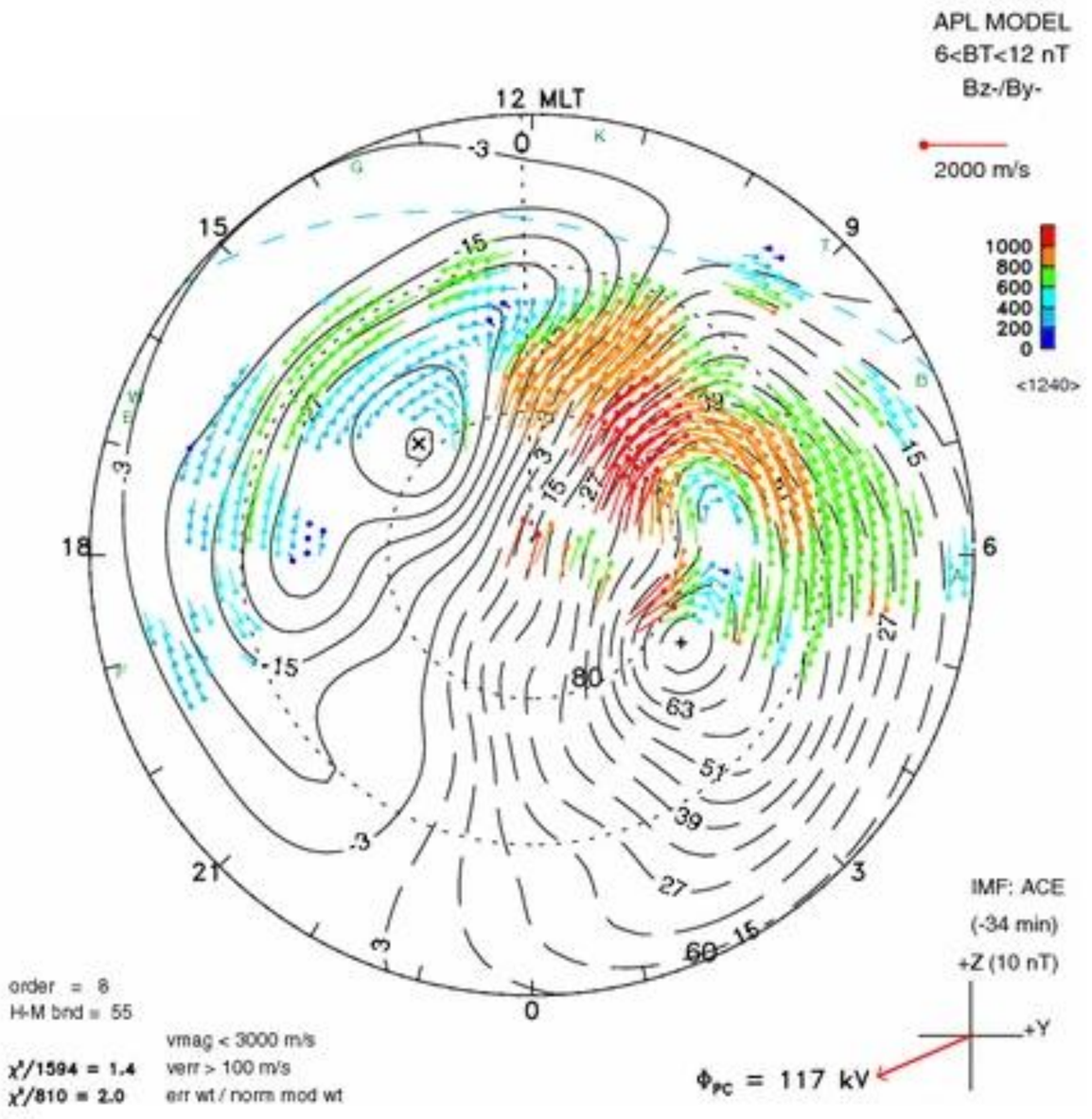
Grocott et al., 2012

Best fit expansion of spherical harmonic functions



Lots of downsides!

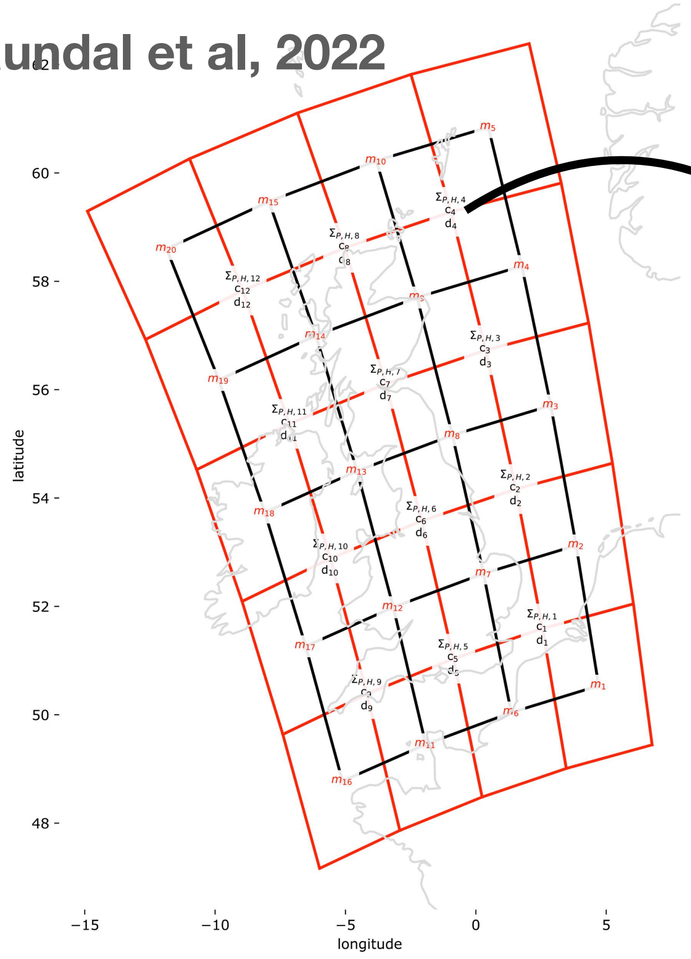
- Spherical harmonic functions are cyclic
- Level of detail (order of fit) is constant over global fit
- Data binned anywhere can affect the global fit
- Boundary condition required

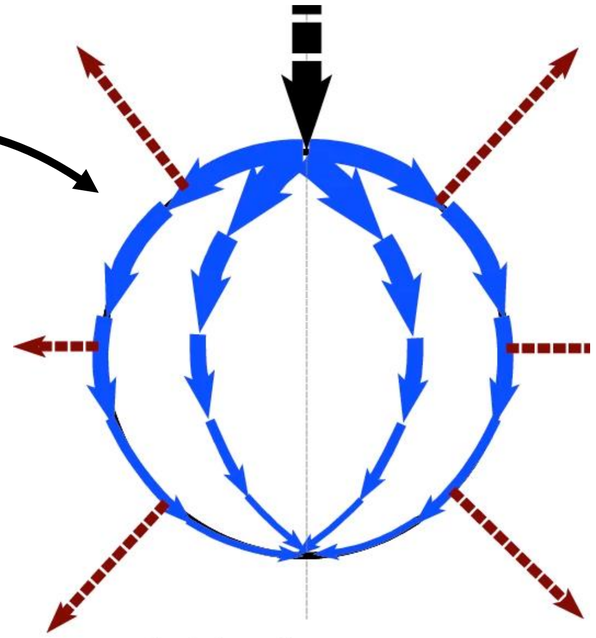


LOcal Mapping of Polar Electrodynamics (Lompe)

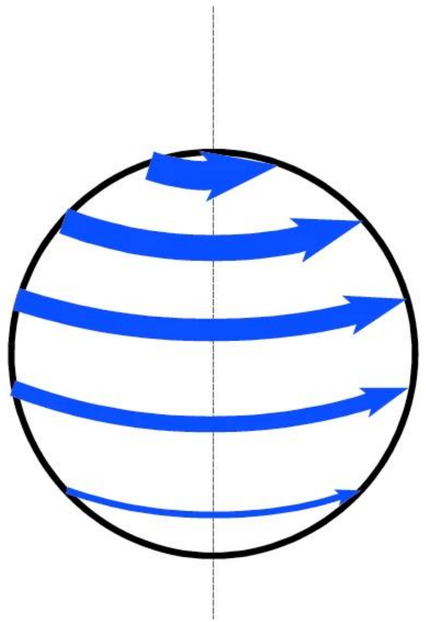
Electric field is directly represented through the sum of divergence-free and curl-free components **(spherical elementary current systems method)**

Laundal et al, 2022





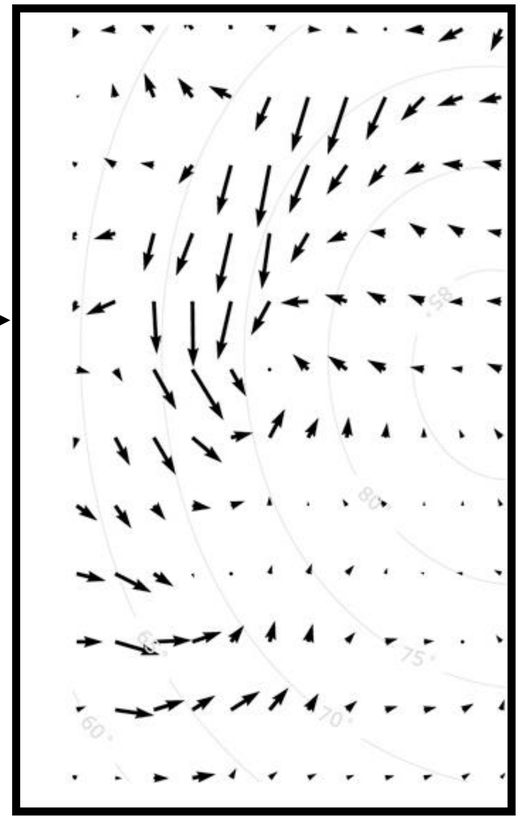
Curl-free elementary system (with associated FACs)



Divergence-free elementary system

Vanhamäki & Juusola, 2019

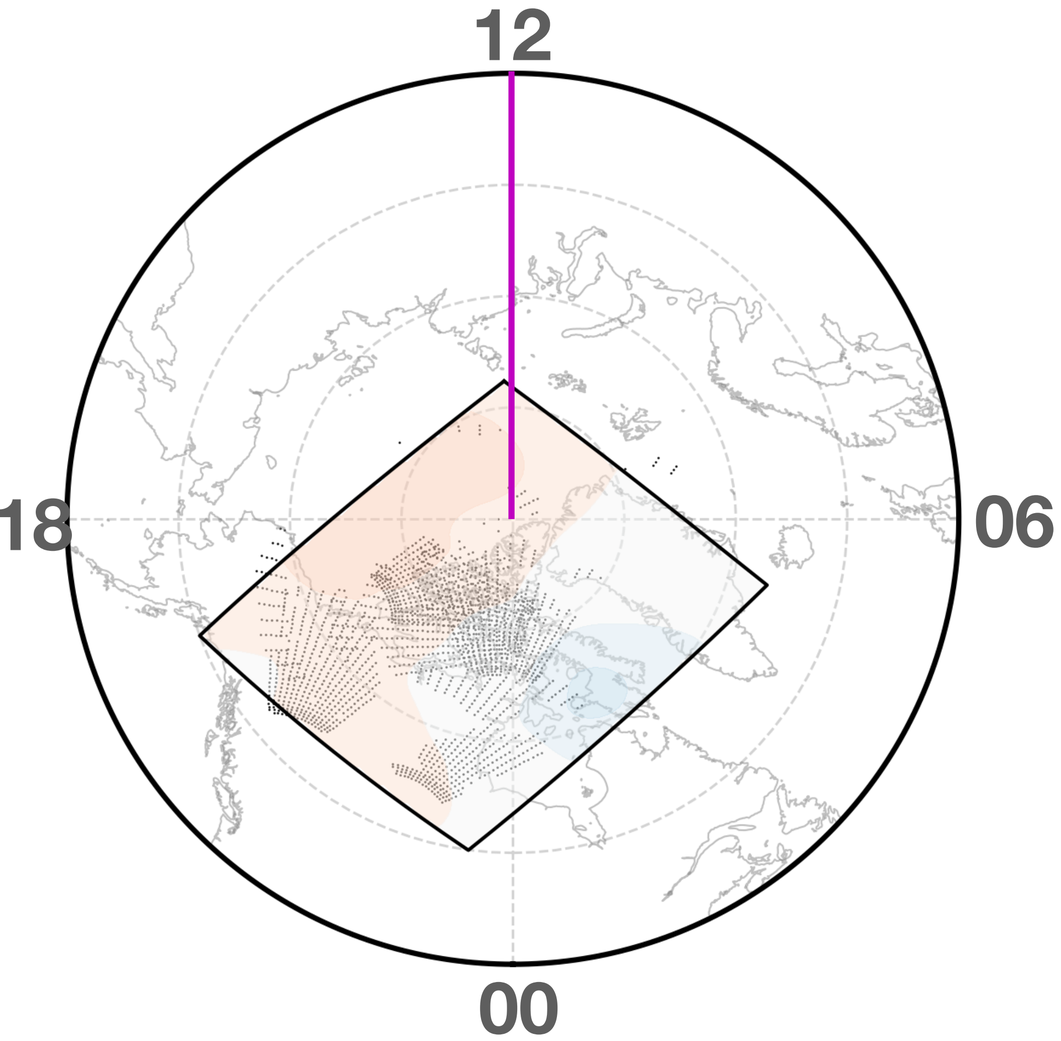
Horizontal currents



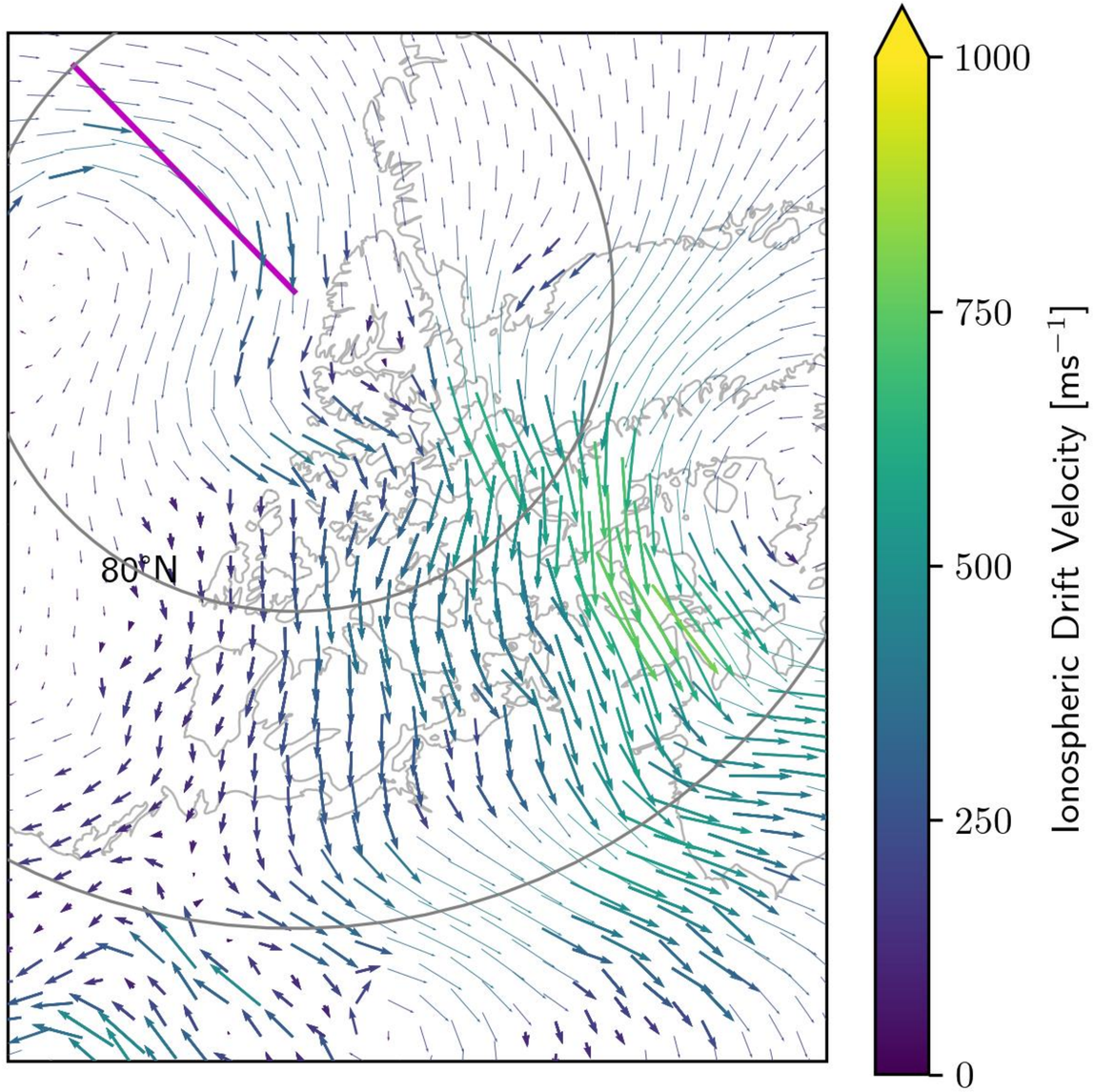
Laundal et al, 2022

LOcal Mapping of Polar Electrodynamics (Lompe)

Electric potential map [MLat/MLT]

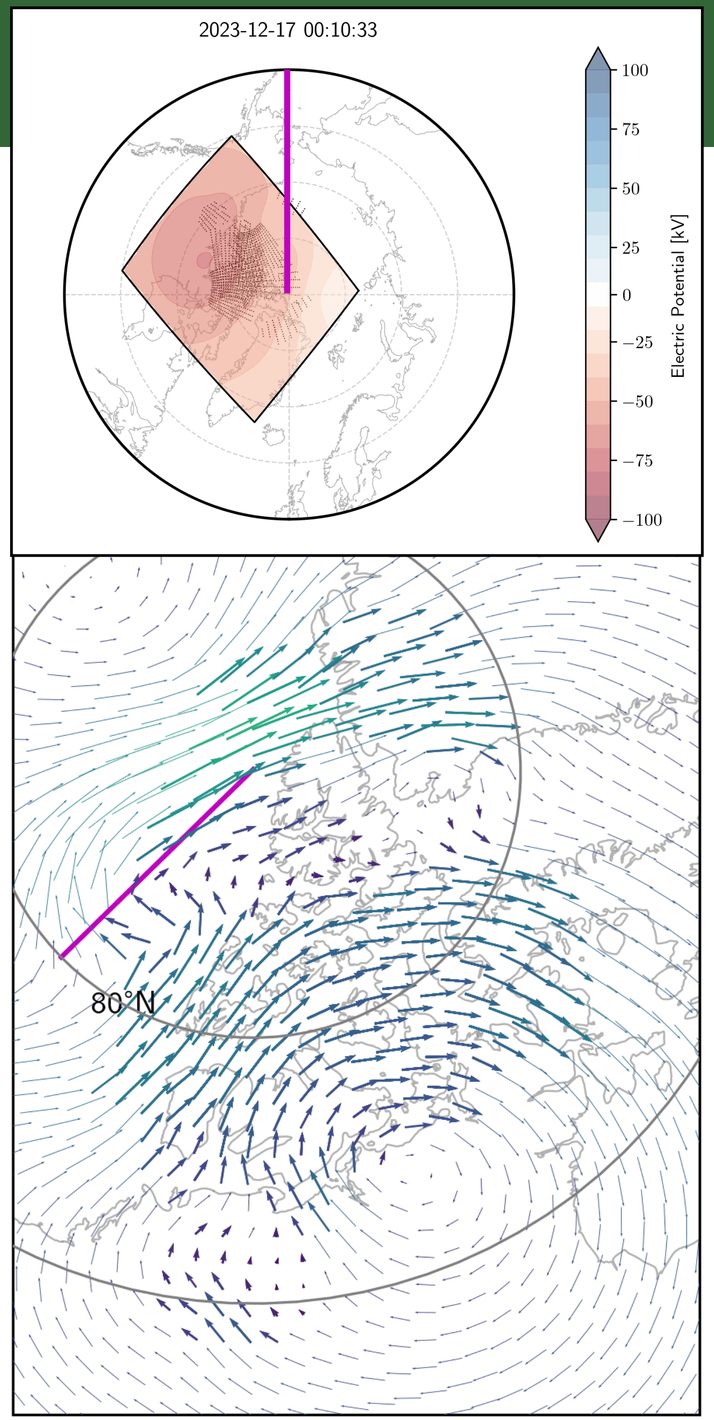


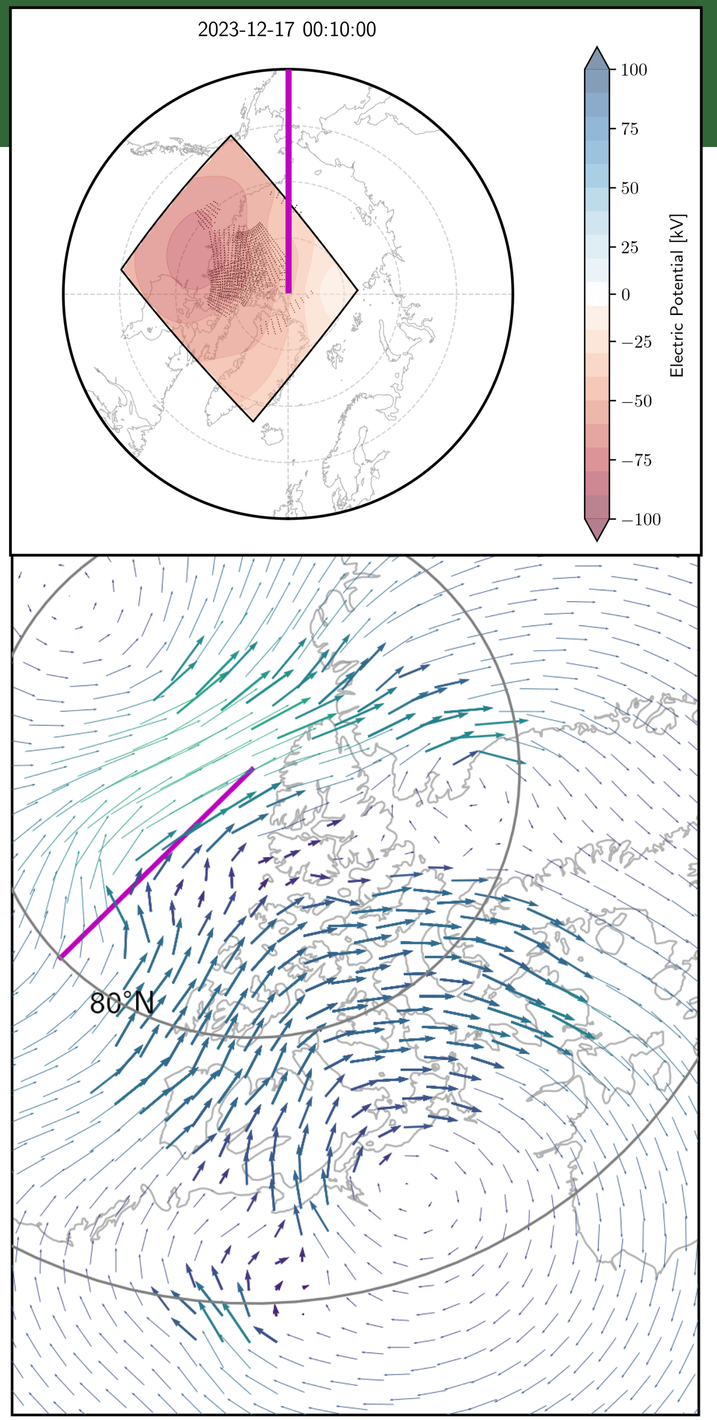
Polar-cap / Canada flow field



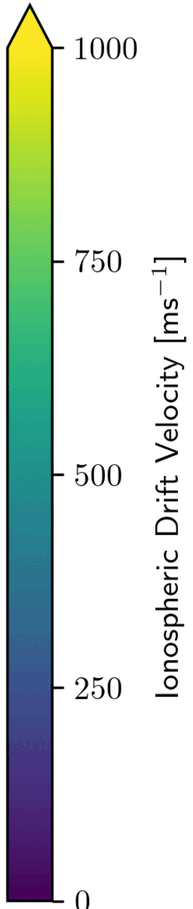
2023-12-17

Traditional narrow-beam scanning



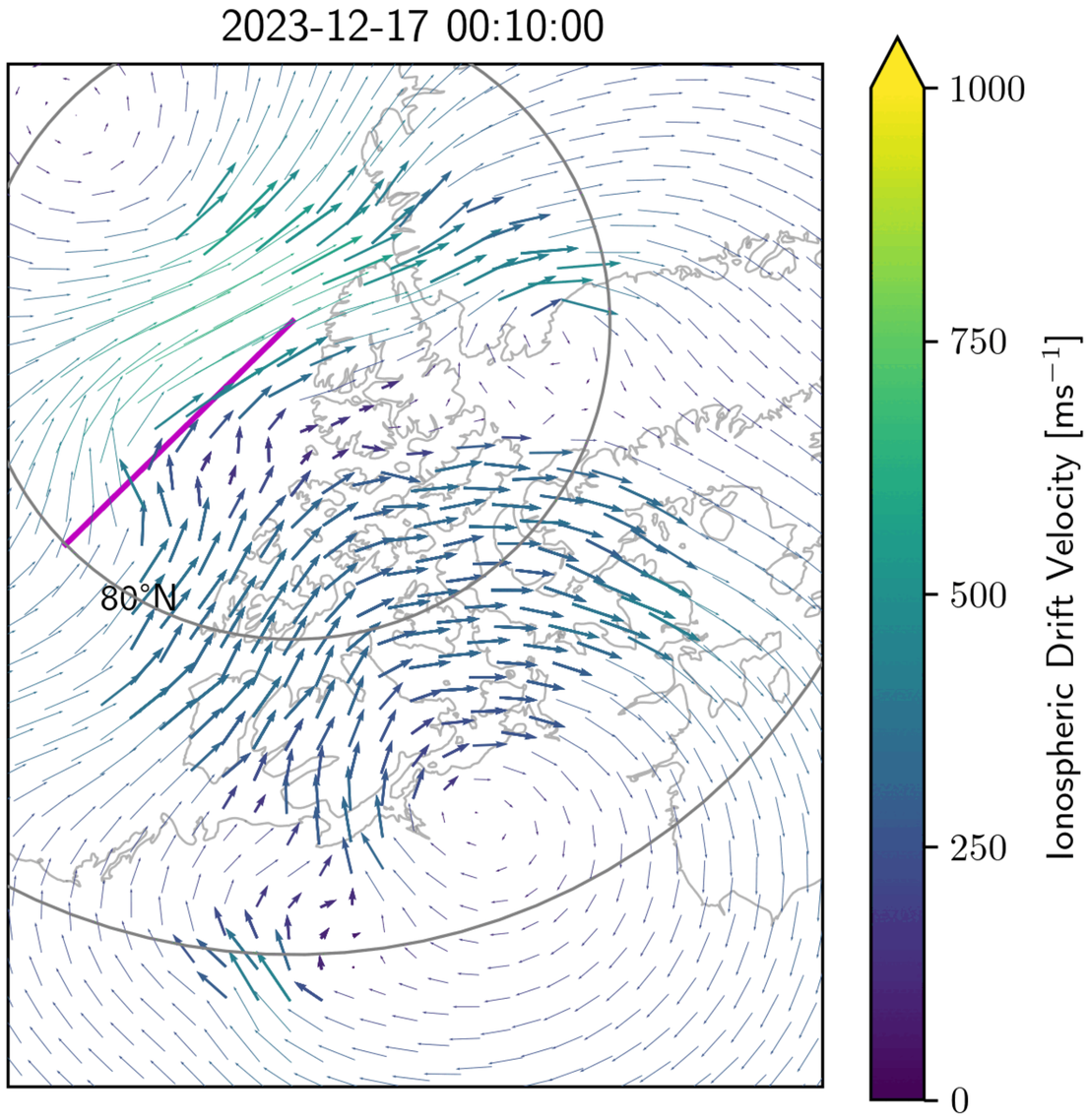


Borealis wide-beam imaging



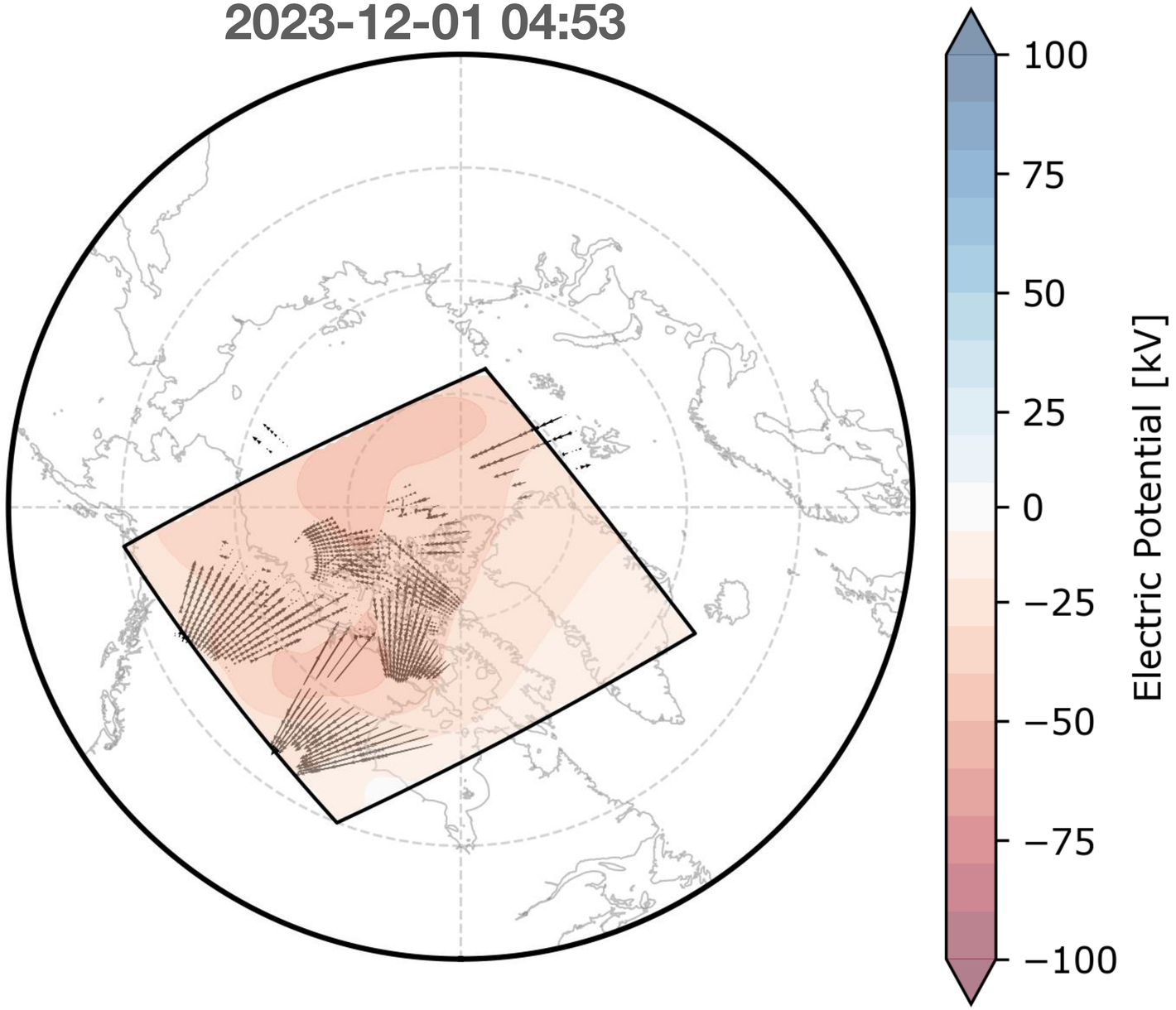
SUPERDARN CANADA

Summary



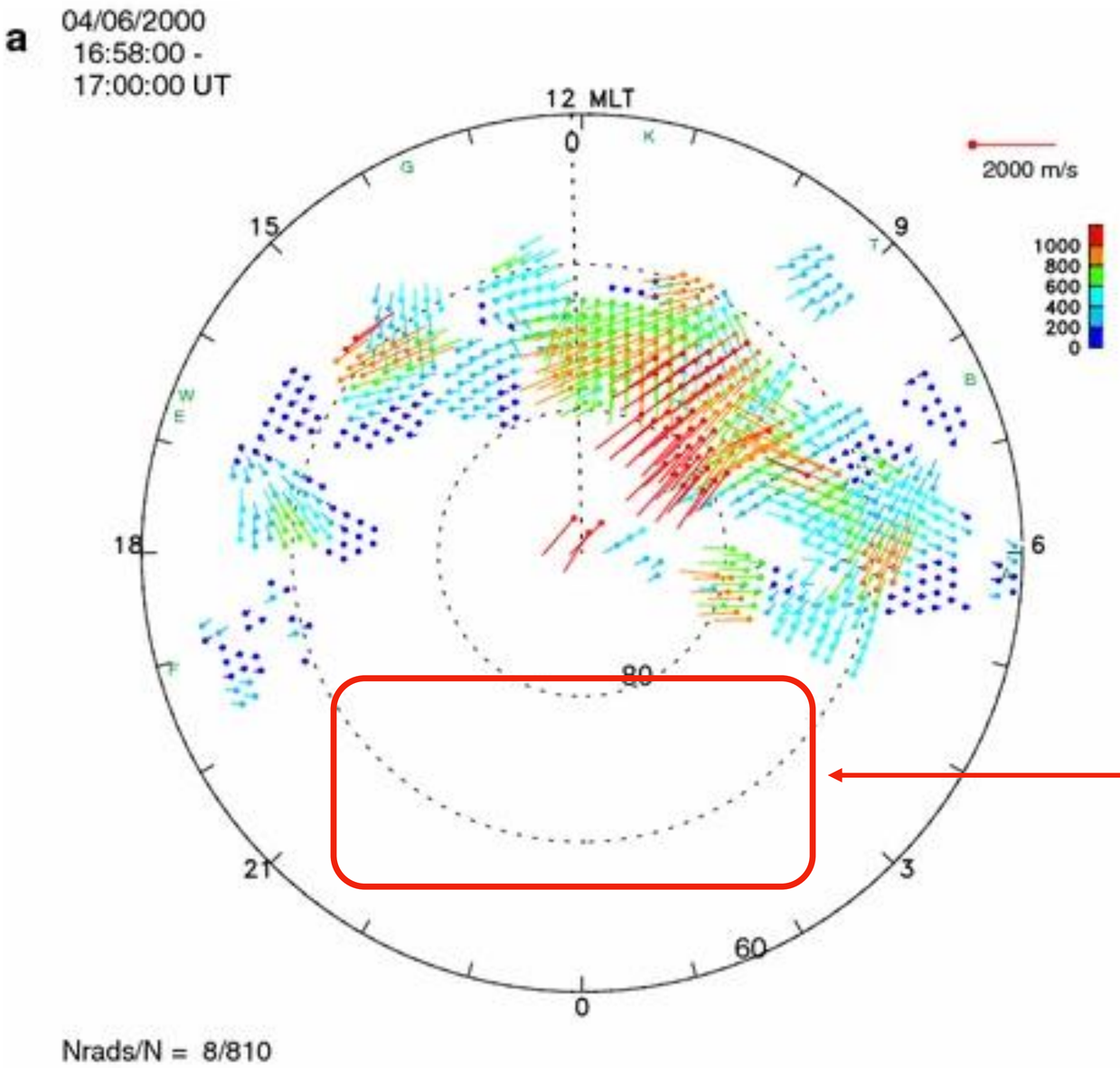
- Using the SuperDARN Canada Borealis imaging capabilities, local ionospheric flow fields can be derived every 3.5 seconds.
- A 16-fold temporal resolution is seen over traditional SuperDARN convection patterns.
- Mesoscale ionospheric features are preserved, and short-timescale variability is finally captured.
- SuperDARN Canada is working to operationalise this new data product ñ hopefully well before SMILE, GDC, etc.

LOcal Mapping of Polar Electrodynamics (Lompe)



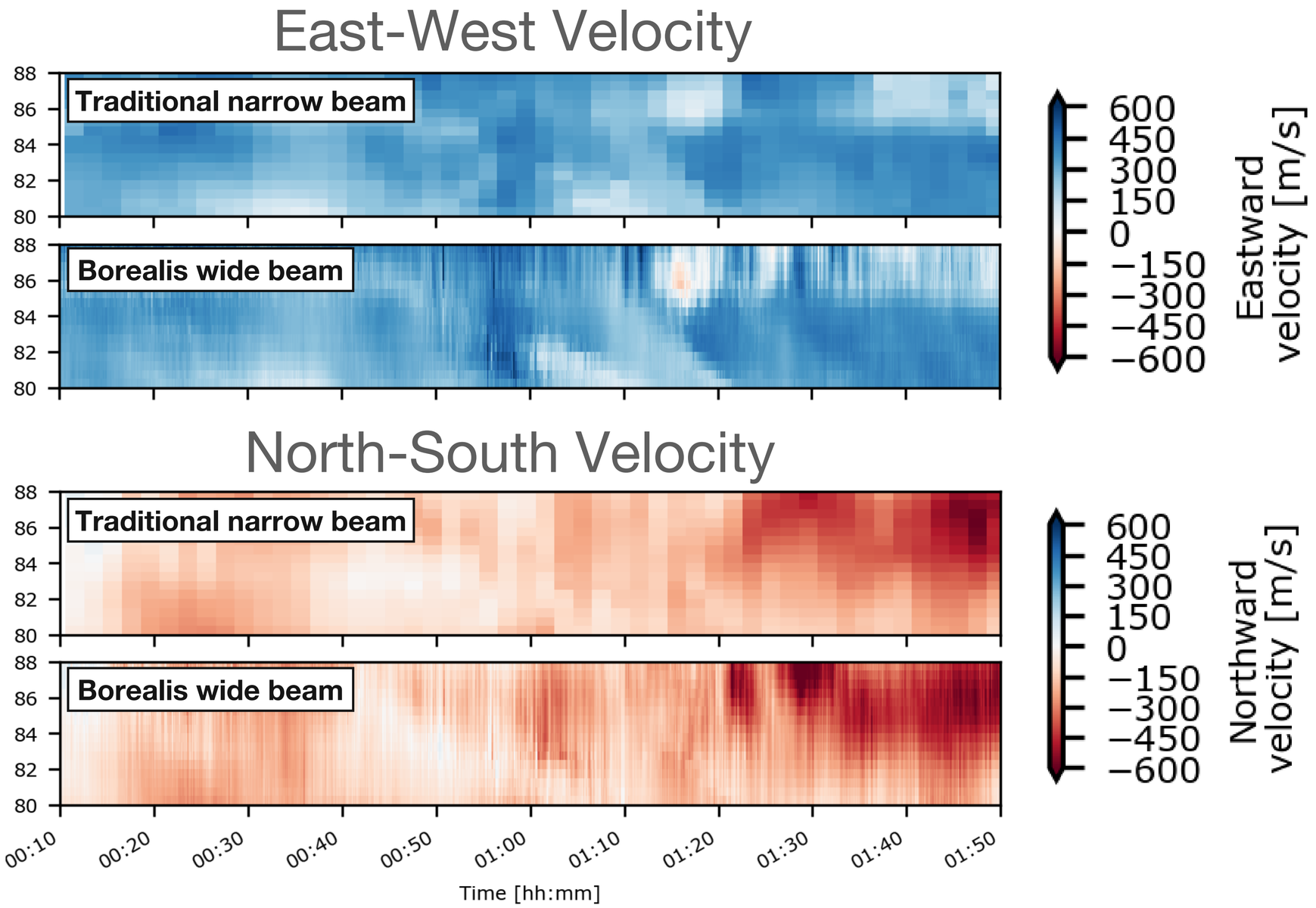
- Fit is now constrained to dense data regions.
- SECS have a short-reach.
- Level of detail is dependent on data density. Mesoscale features preserved.
- No boundary conditions, no prior assumptions about convection ìshouldî look like.
- Errors <5% with ~25% data coverage [Amm et al., 2010, Reistad et al., 2019].

Traditional SuperDARN Convection Patterns



- Collect LOS velocity measurements from all radars
- Grid data into equal area bins
- (Optional) Fill gaps with ìdataî from statistical model

Bonus slide


East-West Velocity
Traditional narrow beam
Borealis wide beam
88
86
84
82
80
600
450
300
150
0
−150
−300
−450
−600
Eastward velocity [m/s]
North-South Velocity
Traditional narrow beam
Borealis wide beam
Northward velocity [m/s]
00:10
00:20
00:30
00:40
00:50
01:00
01:10
01:20
01:30
01:40
01:50
Time [hh:mm]